REMEDIATION WORK PLAN FOR SUBSURFACE SOIL AND GROUNDWATER AT THE FORMER McDONNELL DOUGLAS C-6 FACILITY, PACEL A TORRANCE, CALIFORNIA

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REMEDIATION WORK PLAN FOR SUBSURFACE SOIL AND GROUNDWATER AT THE FORMER McDONNELL DOUGLAS C-6 FACILITY, PACEL A TORRANCE, CALIFORNIA

Prepared for:
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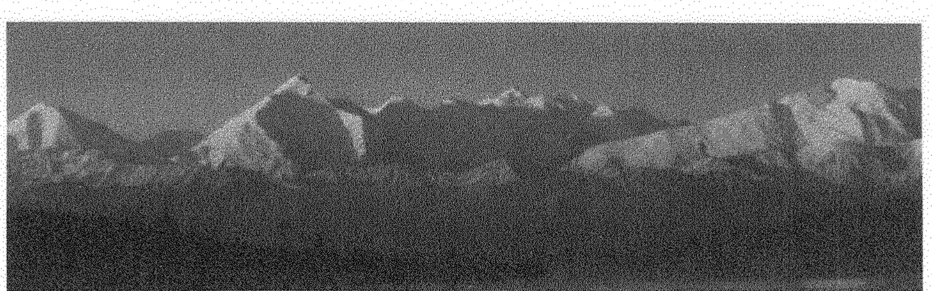

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March 9, 1998

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REMEDIATION WORK PLAN FOR
SUBSURFACE SOIL AND GROUNDWATER AT
THE FORMER McDONNELL DOUGLAS C-6 FACILITY, PARCEL A

1.0 INTRODUCTION

This work plan has been prepared and submitted to detail the tasks associated with the remediation of subsurface soils at former Building 36 and shallow groundwater at the Former McDonnell Douglas C-6 Facility, Parcel A (the site) located at 19503 South Normandie Ave., Los Angeles, California. The location of the site is shown on Figure 1. A site plan of the facility is shown on Figure 2.

The areas with elevated concentrations of chemicals at the site can be divided into three categories:

- hot spots - chemical impacted soil to a depth of less than 12 feet below ground surface (bgs)
- subsurface soil - chemical impacted soil found at depths greater than 12 feet bgs
- groundwater - the shallow underlying saturated zone extending to approximately 90 feet bgs

This remediation work plan presents the remediation approach and technologies to address the subsurface soil and groundwater at the site. Hot spot remediation has already been completed.

The objective of this remedial program is to meet soil and groundwater remediation goals for the site and obtain a "No Further Action" designation from the California Regional Water Quality Control Board, Los Angeles Region (LARWQCB). The proposed remediation approaches are to reduce the concentrations of chemicals in the soil and groundwater to below the remediation goals by vapor extraction and enhanced natural biodegredatation, respectively.

2.0 SITE DATA AND DELINEATION

Data regarding the site and delineation of known or suspected areas of impacted soil and groundwater is based on review of the following reports:

- Douglas Aircraft Company, Torrance (C6) Facility, Phase III Groundwater and Soil Investigation Report, Woodward-Clyde Consultants, 1990

- Groundwater Monitoring Data Summary Report, Second Quarter 1992, Douglas Aircraft Company C-6 Facility, Kennedy/Jenks Consultants (K/J), 1992
- Conceptual Design of Final Soil and Groundwater Remediation System at the Douglas Aircraft Company, C6 Facility, Montgomery Watson (MW), 1994
- Groundwater Monitoring Data Summary Report, Fourth Quarter 1996, McDonnell Douglas Realty Company C-6 Facility, K/J, 1997a
- Groundwater Monitoring Data Summary Report, First Quarter 1997, McDonnell Douglas Realty Company C-6 Facility, K/J, 1997b
- Parcel A - Phase II Soil Characterization, McDonnell Douglas Realty Company, C-6 Facility, K/J 1997c
- Phase I Groundwater Characterization Workplan, Boeing Realty Corporation, C-6 Facility, Parcel A, Integrated Environmental Services, Inc. (Integrated), 1997

The lateral extent of soil and groundwater impacted by chemicals of concern (COC) at concentrations requiring remediation is shown on Figure 3, Soil and Groundwater Plumes. Historical data collected over 10 years of groundwater monitoring from wells WCC-5S, WCC-7S, WCC-9S, and WCC-12S (K/J, 1997b) indicates that the concentrations of COCs in the wells located at the leading edge of the groundwater plume are either stable (WCC-5S, WCC-7S, and WCC-9S) or exhibit a decreasing trend (WCC-12S). This data indicates that the down gradient concentrations of the COCs are not increasing, and that natural attenuation of the COCs at the leading edge of the plume will prevent the future off-site migration of the COCs at concentrations exceeding the target remediation goals.

2.1 Local Geology and Hydrogeology

Extensive information regarding the soils within 50 feet bgs at the facility was developed from the drilling and geologic logging in the Phase II Soil Characterization. The Phase II Report (K/J 1997c) identified four subsurface units, informally designated Q1 through Q4. Unit Q1 extends from the surface to depth varying from 5 to 22 feet and consists of silty and sandy clay. Unit Q2 varies in thickness from 17 to 30 feet and consists of interbedded clayey silt, fine sandy silt, and fine silty sand with minor silty clay lenses. Unit Q3 is greater than 28 feet thick on the west side of the facility and extends to beyond 50 feet bgs to the northwest. Unit Q3 is characterized as an interval of fine or very fine sand with minor silt. Unit Q4 was not observed in the area of the site, but is present in other areas of the facility. The soil in Unit Q4 consists mainly of fine silty sand and clayey silt, with thin interbeds of silty clay and fine sand.

There are two water bearing zones described under the facility. The shallow zone is likely part of a regional Semi-Perched Aquifer. Below the Semi-Perched Aquifer is the Bellflower Aquiclude, separating this water bearing zone from the deeper Gage Aquifer (Integrated, 1997). Below the Bellflower Aquifer at approximately 300 and 500 feet bgs respectively, are the Lynwood and Silverado Aquifers (K/J, 1997c). Groundwater is first encountered at this site at approximately 65 feet bgs.

2.2 Potential Areas of Concern

The review of soil data for Parcel A indicates that the uppermost 12 feet of soil (hot spots) has been successfully remediated. Any residual levels of chemicals in the vicinities of the hot spots are minimal and will not impact soils deeper than 12 feet bgs or impact groundwater. The following are the potential areas of concern in the subsurface soils greater than 12 feet bgs identified within Parcel A:

1. former Building 36
2. boring 2BB-1-6, southwest of Building 41

The maximum concentrations of TCE and 1,1-DCE in boring 2BB-1-6 are detected at 40 feet bgs and are reduced by approximately one half to one fifth in the next sample, collected at 50 feet bgs. Based on the maximum concentrations and the attenuation evidenced in the sampling results, boring 2BB-1-6 is not an area of concern. Based on a review of the available data, Building 36 is an area where chemical concentrations and distribution in soil greater than 12 feet bgs might be of concern.

Subsurface soils in the Building 36 area are defined by a number of borings. These borings showed that the highest concentrations of the COCs are located at approximately 19 to 40 feet bgs. Review of soil data collected from past boring logs in the immediate area show this lithology to be primarily silty clay that continues to approximately 37 feet bgs. Groundwater currently is at a depth of approximately 65 feet bgs. Terra Vac proposes that the soil in the vicinity of Building 36 be remediated to prevent possible migration to groundwater and impact to human health. No soil analytical data has been collected addressing the zone below 50 feet bgs. Review of the soil analytical data above 50 feet bgs shows declining concentrations of contaminants from the 20 foot depth to 50 feet bgs. Boring logs indicate that below 50 feet bgs is a sandy lithology. Therefore, it is assumed that COC concentrations in the soil will continue to decrease below 50 feet and residual COC concentrations will not require remediation below 50 feet bgs.

2.3 Site Hydrogeology

Review of groundwater chemical concentration data indicates that groundwater has been impacted in two portions of the site (K/J, 1997b). Groundwater elevation and gradient data suggests that the concentrations of chemicals detected in the groundwater in the western portion of the site (observation well DAC-P1) are migrating onsite from an off site source. As a result, this area is not addressed in this work plan.

A second area of impacted groundwater is the subsurface in the vicinity of former Building 36. Two water bearing zones are present in this area, a shallow zone ending at approximately 90 feet bgs, underlain by the Bellflower aquiclude, extending to a depth of approximately 100 feet bgs, and the Gage Aquifer, underlying the Bellflower Aquiclude (Integrated, 1997). Groundwater is first encountered at this site at approximately 65 feet bgs. This Work Plan only addresses the shallow zone ending at approximately 90 feet bgs.

Tests performed on the groundwater in the upper water bearing zone indicate that the velocity and hydraulic conductivity are approximately 0.64 feet per day and 715 gallons per day per square foot (Woodward-Clyde, 1990), respectively. Groundwater flow direction of the shallow water bearing zone within Parcel A has generally been to the south (K/J, 1992, 1997a and 1997b).

3.0 REMEDIATION OBJECTIVES

The remediation objective for this project is to obtain a "No Further Action" designation from the CRWQCB. A review of the most recent groundwater sampling data indicates that several COCs at the site are present in the groundwater at concentrations exceeding the target remediation goals. Table 1 lists the COCs, the highest concentration observed in the groundwater, and the remediation goal for that chemical. Groundwater target remediation goals may be revised if the reduction in concentrations of COCs in the groundwater reaches an asymptotic level

Table 1
COCs Concentrations in Groundwater

COC	Maximum Concentration micrograms per liter (µg/L)	Well	Target Remediation Goal (µg/L)
1,1-Dichloroethane (DCA)	140	WCC-3S	5
1,1-Dichloroethylene (DCE)	7,000	WCC-6S	6
cis-1,2-DCE	2,000	WCC-3S	6
trans -1,2-DCE	180	WCC-3S	10
Toluene	9,100	WCC-3S	150
1,1,1-Trichloroethane (TCA)	740	WCC-6S	200
Trichloroethylene (TCE)	2,700	WCC-1S	5

Note:
µg/l - micrograms per liter
Concentration data from First Quarter 1997 Groundwater Monitoring Report (K/J, 1997b)

4.0 REMEDIATION TECHNOLOGY OVERVIEW

4.1 Soil Remediation

Soil remediation will be accomplished by utilizing soil vapor extraction. This technology is widely used to remove volatile organic compounds (VOCs) from subsurface soils. A blower is used to apply a vacuum to wells screened in the impacted soil zone, causing a pressure differential in the subsurface and inducing vapor flow towards the wells. Residual VOCs in the soil are volatilized into the vapor phase and are conveyed to the wells and then to a treatment compound. Several technologies are utilized to remove the VOCs from the vapor stream before the vapors are exhausted to the atmosphere. For this project, Terra Vac will utilize carbon adsorption to accumulate the VOCs into vessels containing granulated, activated carbon (GAC). The GAC is subsequently regenerated or disposed of off site.

4.2 Groundwater Remediation

To address the delineated groundwater plume, biostimulation will be applied by injecting air and nutrients into the groundwater using horizontal wells. Horizontal wells were chosen as the most cost effective method of applying the technology without interfering with property development and minimizing the number of above ground access points required for system operation and maintenance. The biodegradation of the COCs will take place by enhancing the ability of indigenous aerobic bacteria to carry out degradation of chlorinated compounds as well as aromatic compounds. This technology has been applied at a multiple sites and has been shown to degrade chemicals in groundwater in a relatively short period of time, without pumping and or treating groundwater ex-situ.

The biologic pathway for the degradation of TCE and DCE is dechlorination, where TCE is degraded to DCE, then to vinyl chloride (VC), and finally to ethene, ethane, chlorine, and other innocuous chemicals. Bench scale studies conducted on samples collected at the site indicate the feasibility of bioremediation to degrade the COCs (MW, 1994). Research conducted on the bioremediation of chlorinated solvents indicates that partially dechlorinated compounds (i.e. VC) do not accumulate when there is a zone of aerobic bioremediation (Fathepure et al, 1995).

Nutrient levels must be maintained in the subsurface to ensure that the existing population of microorganisms have sufficient nutrients to degrade the COCs. The three major elements commonly required at sites to enhance biodegradation are nitrogen, phosphorus, and sulfur. The most readily available sources of these elements include: nitrate, urea, and ammonium for nitrogen; ortho-phosphate, triple superphosphate, and polyphosphate for phosphorus; and sulfate and polysulfides for sulfur. In addition to those three elements, there are another six major elements which may be required at a particular site to foster biodegradation, potassium, iron, magnesium, calcium, sodium, and chloride.

4.3 Prevention of Migration of Chemicals Due to Air Injection

The forced migration of COCs in the groundwater from the air injection wells is a potential limitation of air injection technology. If the air injection causes a gradient in the groundwater surface away from the wells (mounding), then there is a potential to cause the migration of COCs away from the wells. This can be mitigated by pulsing the injection of the air, allowing the air to enter the aquifer and migrate through diffusion, rather that the constant pressure differential caused by the pressurized air in the well, and by limiting the flow rate and injection pressure. Pulsing the air injection system prevents the formation of a permanent mound in the groundwater surface by allowing the groundwater to fill the pore spaces occupied by the pressurized air, causing a temporary depression in the water table and causing limited migration towards the well, negating the potential effect of the mounding. Groundwater elevation readings at the site will be used to determine if mounding is effecting the groundwater gradient and flow direction by comparing the data to historical information.

5.0 SCOPE OF WORK

The project scope of work consists of the following tasks:

- permitting
- nutrient optimization study
- remediation system installation
- remediation system operation and maintenance
- groundwater monitoring
- confirmation sampling
- closure report preparation
- site restoration and demobilization

5.1 Permitting and Regulatory Approval

Terra Vac will obtain the necessary permits to construct and operate the soil and groundwater remediation systems from State and local agencies including South Coast Air Quality Management District (SCAQMD) permits to construct and operate the soil remediation system, well permits, and building permits. Terra Vac will also obtain a waste discharge requirement from the LARWQCB for the injection of nutrients in to the groundwater.

5.2 Soil Remediation System Installation

The soil remediation system will consists of two elements, 12 vapor extraction wells, and a vapor extraction blower and associated vapor remediation equipment. The vapor extraction blower and remediation equipment will be located in a remediation compound near the former location of Building 36.

5.2.1 Vapor Extraction Well Installation and Design

A total of 12 vertical wells will be installed concentrating on two areas located near the former northwest and southwest corners of Building 36. These locations correspond to the areas with the highest concentrations of VOCs in the vicinity of former Building 36 based on previous soil borings 2BB-36-2, 2BB-36-7, 2BB-36-8, 2BB-36-9, and 2BB-36-13 (K/J, 1997c) The location of these wells is shown on Figure 4, Proposed Vapor Extraction Well Locations. The VE wells will be multi-completed, consisting of "nested" well casings. Each of these well casings will have a screen section targeted at a specific soil type or a segment of thicker soil zone with elevated relative VOC concentrations. Based on previous vapor extraction tests conducted at the site (MW, 1994), the estimated radius of influence (ROI) for the proposed VE wells is 15 feet.

The borings will be advanced using a 10-inch outside diameter hollow stem auger. Soil samples will be taken every five feet and screened in the field for relative VOC concentrations using an organic vapor analyzer. Geological profile of the soil cuttings will be logged by a Terra Vac geologist in accordance with Unified Soil Classification System protocols. Sample collection and routine well completion protocols are included from Terra Vac's Standard Operating Procedures, included in Appendix A. Selected soil samples will be submitted to a State of California certified laboratory and analyzed for VOCs by USEPA method 8260. The borings will be terminated at 50 feet bgs.

The wells will be constructed of 2-inch diameter schedule 40 polyvinyl chloride (PVC) pipe, with approximately 10 feet of PVC 0.02-inch slot size screen at the bottom of the well. A standard well construction schematic is included in Appendix A. Monterey #2/12 sand will be used to fill the annular space. The vapor extraction wells will be completed five feet below existing grade and trenched at a similar depth to the system compound in order to facilitate future development.

Excavated soils from drilling activities will be temporarily stored on-site in 55-gallon drums, labeled, and stored onsite. Upon receipt of analytical results, the excavated soils will be properly disposed.

5.2.2 Vapor Extraction Blower and Remediation Equipment

The vacuum extraction wells will be manifolded into a water/vapor separator, and from there into the vapor treatment system and the vapor extraction blower prior to being exhausted to the atmosphere. The water/vapor separator will have at least a 55-gallon capacity and will be grounded to avoid the possibility of electrical ignition of the extracted vapors. The water/vapor separator will be equipped with a transfer pump and an automatic level switch so that the vessel may be emptied automatically into storage drums. The vapor treatment system will use two 1,000 pound activated carbon vessels to absorb extracted COCs in the vapor phase. A positive displacement 40 horsepower blower capable of 15 inches of mercury (" Hg) and up to 300 cubic feet per minute (cfm) will be installed and utilized as the vapor extraction blower.

The blower will be installed on the vacuum side of the carbon vessels to prevent the possibility of high vapor discharge temperatures igniting the vapors in the drums, and to prevent failure of the piping or fittings allowing the venting of COC laden vapors from venting to the atmosphere. The blower will be equipped with a high temperature shut off, a flow meter, and an hour meter to estimate the total volume of air processed by the remediation equipment.

5.2.3 Treatment System Compound

Terra Vac will install a treatment system compound as shown on Figure 5. The compound will be secured with a 6 foot chain-link fence with privacy slats. The treatment system compound will contain the site remediation equipment, as well as an electrical distribution center. Power will be supplied by Boeing from a new or existing power source. An Electrical Distribution Diagram is included as Figure 6. The blowers are equipped with individual enclosures and sound deadening material, and will comply with local zoning ordinances regarding noise. Emergency contact information for Terra Vac will be posted on the outside of the remediation compound.

5.3 Soil Remediation System Operation and Maintenance

The extraction system will be monitored closely during the first four weeks of operation (start-up period) in order to optimize the effectiveness of the system and to verify proper function of the treatment equipment. Thereafter, Terra Vac will monitor the system in compliance with the SCAQMD permit to operate.

Relative extraction rates will be determined based on monthly measurements of the individual well and system inlet vapor concentrations using an OVA or laboratory analytical results using USEPA method 8260, and the corresponding flow rates of the wells and the system. Estimates for the radii of influence on each of the extraction wells will be made based on the observed flow rates and the geologic information obtained during well installation.

Terra Vac will operate, maintain, and monitor the vacuum extraction system as needed to maintain optimal COC removal rates. Liquids captured in the liquid/vapor separator will be containerized, labeled, analyzed, and disposed of accordingly.

5.4 Confirmatory Soil Sampling

Target remediation goals for soil will be based on USEPA or LARWQCB approved fate and transport and health risk assessment models. The soil remediation goals will be established such that the remaining concentrations of COCs in the soil do not pose a threat to human health or the environment, and that the COCs are not present in sufficient concentrations to impact groundwater above the groundwater target remediation goals.

To monitor the progress of the soil remediation and confirm that the remediation goals have been met, up to two sets of "interim borings" will be installed. After one year of vapor extraction system operations two borings will be advanced and sampled. These borings will be advanced to 50 feet bgs and sampled every five feet. Soil samples will be screened in the field using an OVA and selected soil samples will be sent to a California certified laboratory for analysis for VOCs using USEPA Method 8260. Two additional borings may be similarly installed after 18 months of vapor extraction operations.

5.5 Nutrient Optimization Study For Groundwater Remediation

The following subtasks are required for the Nutrient Optimization Study:

5.5.1 Aquifer Sediment Batch Collection

One soil boring will be installed in the vicinity of the former southwest corner of Building 36 and will be extended to a depth of approximately 85 feet bgs, or approximately 20 feet into the saturated zone for the purpose of collecting sediments from the saturated zone. The boring location was selected so that additional groundwater and aquifer sediment data could be gathered from the groundwater plume source area. During the advancement of the boring through the saturated zone, samples of the aquifer sediments will be collected at uniform depths across the saturated zone in stainless steel sleeves using a California-modified split spoon sampler. A total mass of approximately 20-25 kilograms of the aquifer sediments will be collected. The soil boring will subsequently be converted to a vapor extraction well for the soil remediation system. Soil samples will also be collected from the soil zone extending from 50 feet bgs to first encountered groundwater to assess the horizontal extent of impacted soil in this area.

5.5.2 Soil Batch Characterization

The aquifer sediment sample will be composited and divided into two homogenized batches. Terra Vac proposes to collect two replicate composite sediment samples from the homogenized aquifer sediment batch, each of sufficient volume to conduct analyses of: organic contaminant concentrations, total organic carbon, the various forms of nitrogen and phosphorus, potassium, iron, magnesium, calcium, sodium, chloride, pH, pH buffering capacity, grain size analysis, bulk density, and cation exchange capacity. The characterization data will provide an indication of whether or not the existing natural nutrient content of the sediment is at a sufficient level to support appreciable rates of contaminant biodegradation, and which nutrients, if any, must be amended to the subsurface to stimulate biodegradation in the sediment.

5.5.3 Nutrient Screening Evaluation

Based on the results of the analyses conducted during the soil batch characterization, Terra Vac will conduct a nutrient screening evaluation to identify the optimum forms of the macronutrients (especially nitrogen and phosphorus) required to stimulate microbial activities. A respirometry system will be utilized for this evaluation to gauge the levels of microbial activity using oxygen consumption as a qualitative gauge.

5.5.4 Nutrient Optimization Study

Based on the results of the nutrient screening evaluation, Terra Vac will conduct a nutrient optimization study. This study, based on established industrial optimization protocols, is a comprehensive nutrient evaluation designed to identify the best combinations and concentrations of nutrients to maximize the rate of organic contaminant biodegradation in the contaminated soil. A combination of respirometry and analyses of changes in COC concentrations over time will be used to evaluate the performances of the different nutrient mixture treatments.

5.5.5 Nutrient Formulation Selection Application Design

Once the optimum nutrient formulation has been identified in the optimization study, Terra Vac will prepare sufficient quantities of the formulation for use in the full-scale treatment system. A nutrient delivery system will be designed and installed with the biosparging system to deliver the nutrients to the aquifer.

The nutrient formulation will be applied intermittently and in a "pulse-type" mode to minimize the potential for excessive biofouling of the aquifer sediments in the immediate vicinity of the subgrade nutrient delivery system. The air injection lines will be utilized to transport the nutrients from the treatment compound to the injection wells. Nutrients may be added to the air lines by use of injection pumps or venturis.

5.6 Groundwater Remediation System Installation

The groundwater remediation system will consist of two elements, three horizontal wells to deliver nutrients and air to the aquifer, and a biosparging blower and nutrient delivery system. The biosparging blower and nutrient delivery system will be located in the treatment system compound.

5.6.1 Horizontal Well Installation and Design

Three horizontal biovent wells will be installed laterally under the groundwater plume as shown on Figure 7, Proposed Horizontal Well Locations. The well locations are selected so that the air will be injected into the aquifer in the areas exhibiting the highest historical concentrations of the COCs. By injecting the air and nutrient into these areas, the source areas will be remediated directly, reducing the concentrations of COC that migrate down gradient form these areas. Additionally, dispersion and diffusion will transport the increased dissolved oxygen concentrations and nutrients down gradient. The well locations are situated across the groundwater gradient (K/J, 1997b), as opposed to along the axis of the gradient. By placing the wells across the gradient, the wells create a zone of microbial activity analogous to a barrier wall. Based on previous aquifer testing data collected by Woodward Clyde in 1990, it is estimated that the groundwater at the site travels approximately 700 feet in three years. The wells are also situated such that groundwater that has migrated past one of more of the horizontal wells will reach the boundaries of Parcel A within three years.

The three wells will be connected to an air and nutrient injection system. The piping from the system will be installed above grade except within the confines of Parcel A, where the piping will be placed in trenches approximately 5 feet bgs.

The horizontal wells will be installed using a directional drill rig which bores down from grade level at a steep angle, through the water table at 65 feet bgs to the target depth of 75 feet bgs. Once this depth is encountered, the drill bit is controlled via remote to transition from a vertical or declining trajectory to a horizontal course parallel with grade surface.

The horizontal wells will be completed using 4-inch diameter high density polyethylene (HDPE) pipe. The tail end of each horizontal well will be fusion welded with a butt cap. The top of both well screen sections will be sealed to grade surface with a bentonite/cement grout with the appropriate cap (either asphalt or cement). The wells will be connected to a source of pressurized air and used to inject air at low-flow rates.

Soil and groundwater samples cannot be collected during horizontal well installation. Drilling mud generated during the horizontal drilling activities will be stored in waste bins and stored onsite. Upon receipt of analytical results, the excavated soils will be appropriately disposed.

5.6.2 Biosparge Blower and Nutrient Delivery System

The three horizontal biovent wells will manifolded via HDPE piping above grade into an oilless compressor capable of providing up to 950 actual cubic feet per minute (acfm) of compressed air at 20 pounds per square inch gauge (psig) pressure. The injection system is capable of delivering up to approximately 2.3 acfm per foot of screened interval, if each the wells are operated singly.

5.7 Groundwater Remediation System Operation and Maintenance

The air injection system will be operated such that the air is injected into each well in alternative intervals. This will, in effect, pulse the injection of the air, minimizing the potential to increase the migration of the COCs away from the wells. Injecting air into only one well at a time will also allow for injection of up to the maximum air flow from the injection blower, and prevent the preferential distribution of air and nutrients into one well other the other. The system will initially be operated so that each well receives air for 4 hours. Each well will be operated twice daily. This schedule may be adjusted after start-up to reduce mounding, increase bioremediation activity in the vicinity of one well, or maintain optimal operating conditions.

Progress of the groundwater bioremediation will be measured based on ongoing quarterly groundwater monitoring activities. Parameters such as the concentrations of COCs, dissolved oxygen concentration, microorganism plate counts in groundwater and Reduction/Oxidation potential may be measured and compared to baseline values to quantify and qualify bioremediation progress. Groundwater surface elevations will be monitored twice every quarter for the first four quarters of operation and quarterly thereafter to determine if the air injection system is increasing the migration of the COCs away from the injection wells by determining if the hydraulic gradient has been affected by the injection system.

Periodic evaluation of the operating parameters such as flow rate, injection pressure and operating hours of the low-flow air injection system will be performed as necessary. Maintenance for the system components will be performed in accordance with the manufacturer's specifications to minimize system down-time. Operating data and analytical data collected during the bioremediation program will be complied and summarized in quarterly reports. Based on the groundwater flow velocities at the site, an estimated three to five years of enhanced bioremediation is required to meet the remediation goals.

5.8 Bioremediation Parameter Monitoring

Terra Vac will sample three wells quarterly to monitor for progress of the bioremediation program in addition to the ongoing quarterly monitoring program. Collected water samples will be analyzed for microbial population and nutrient levels.

5.9 Confirmatory Groundwater Sampling

Ongoing quarterly groundwater monitoring data will be used to determine when the concentrations of COCs in the groundwater have been reduced to below the remediation goals. Terra Vac proposes that the criteria for closure be set based on the following conditions:

1. concentrations of COCs exceeding the remediation goals are not detected in down-gradient monitoring wells MCC-5S and MCC-9S
2. the concentrations of COCs in monitoring wells WCC-1S, WCC-3S, WCC-6S and WCC-8S are reduced to below the remediation goals for three consecutive quarterly monitoring periods
3. The concentrations of COCs in monitoring wells WCC-1S, WCC-3S, WCC-6S and WCC-8S remain below the remediation goals for one additional quarterly monitoring period after the remediation system has been shut down

5.10 Closure Report Preparation

Upon completion of remediation, a closure report will be submitted which will include a site history and chronology of events, a description of the remedial design employed, operational data, and results of confirmatory groundwater analyses.

5.11 Site Restoration and Demobilization

All remedial equipment (including above grade manifolding, compound, utility service equipment, and connections), used in conjunction with this remediation system will be demobilized from the site once closure has been granted by the LARWQCB. All subsurface equipment including the biovent wells and the injection piping will be closed in place by pressure grouting the piping.

6.0 HEALTH AND SAFETY

The purpose of the Health and Safety Plan is to provide for the safe installation and operation of the remediation system. The procedures contained in this plan apply to all personnel, subcontractors, and visitors on-site. A Health and Safety Plan will be submitted prior to commencing field activities. The Health and Safety Plan will comply with the health and safety requirements established for the site.

7.0 REFERENCES

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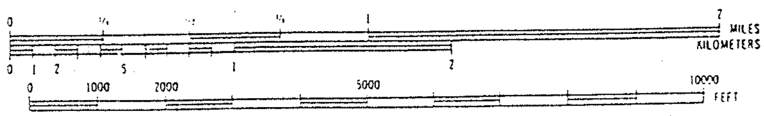
Figures

SITE

SCALE OF MAP PAGES



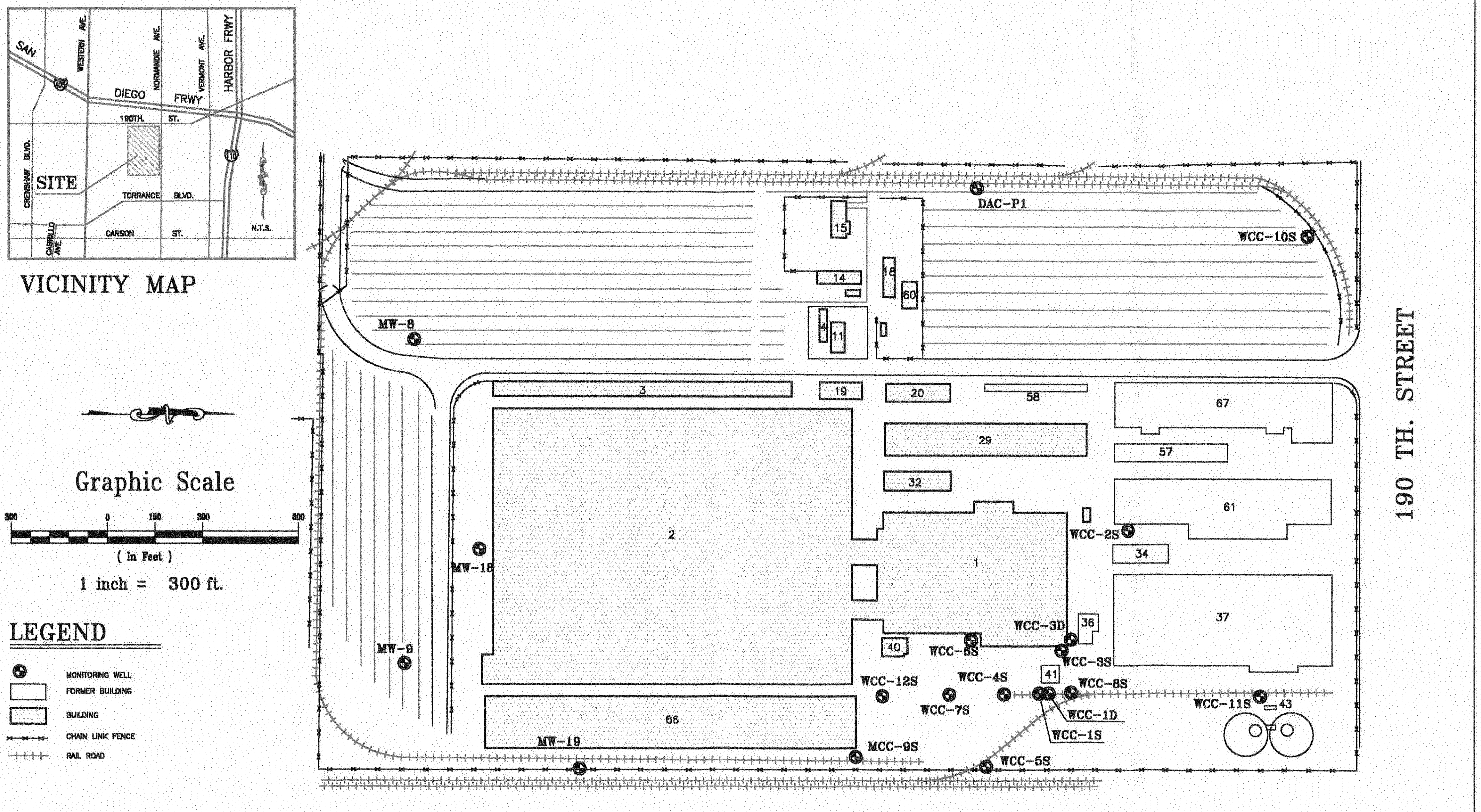
REV	DATE	DESCRIPTION

TERRA VAC
17821 MITCHELL AVENUE
IRVINE, CA 92614-6003

SITE LOCATION MAP

FORMER McDONNELL DOUGLAS C-6 FACILITY
TORRANCE, CALIFORNIA

DRAWN BY: MSH	CHECKED BY: MSH	PROJECT NO: 31-0285	FIGURE 1
APPROVED BY: MSH	DATE: 1/15/97	SCALE: AS SHOWN	



REV	DATE	BY	CHECK	APP	DESCRIPTION

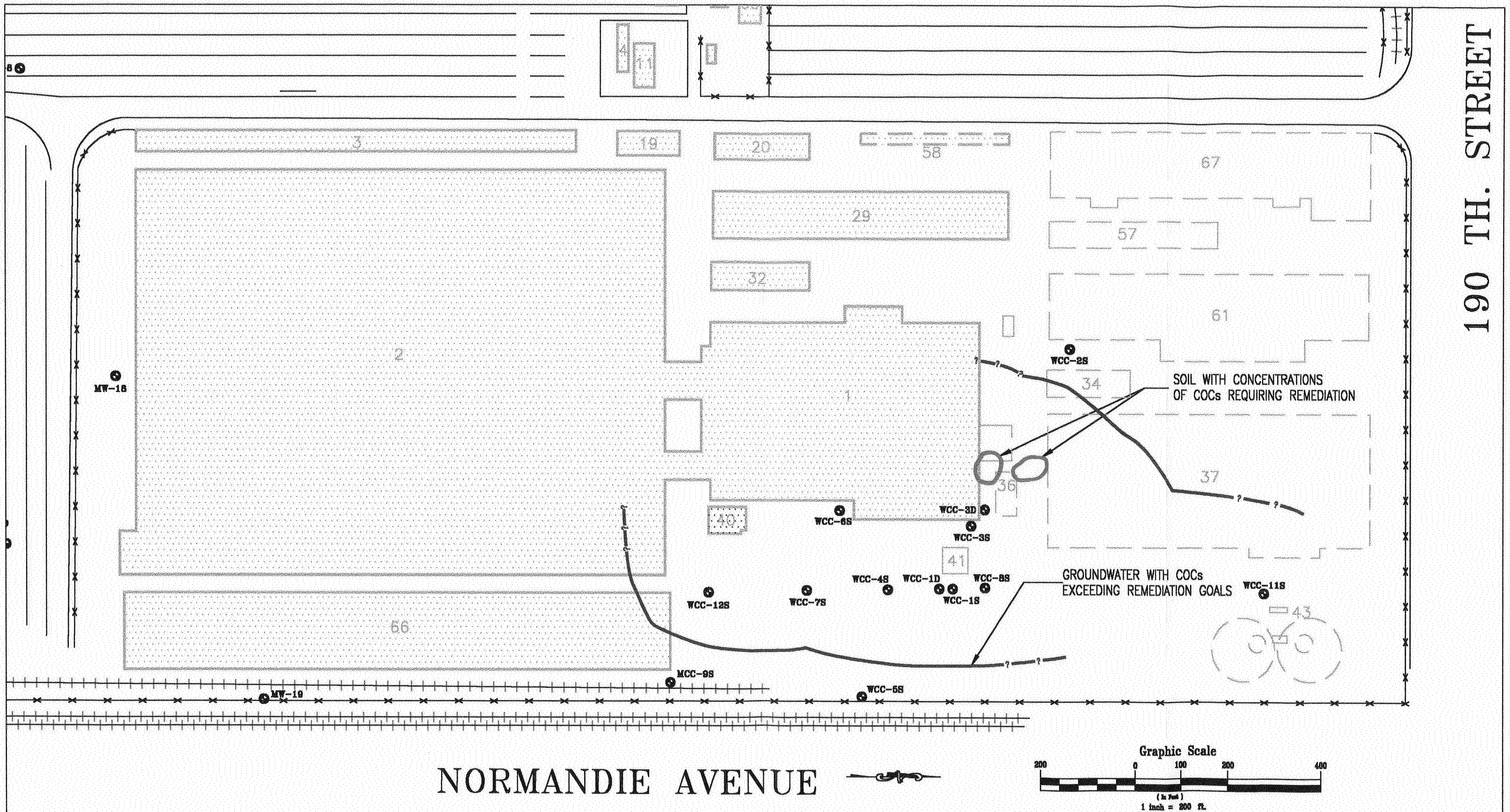
TERRA VAC
17821 MITCHELL AVENUE
IRVINE, CA 92614-6003

SITE PLAN
FORMER McDONNEL DOUGLAS
AIRCRAFT C-6 FACILITY

DRAWN BY: C. CARLOS	CHECKED BY: msH	PROJECT NO: 31-0285
APPROVED BY: msH	DATE: 12/18/97	SCALE: AS SHOWN

FIGURE 2

BOE-C6-0095765



REV	DATE	BY	CHECK	APP	DESCRIPTION

LEGEND

- FORMER BUILDING
- BUILDING
- CHAIN LINK FENCE
- RAIL ROAD
- MONITORING WELL

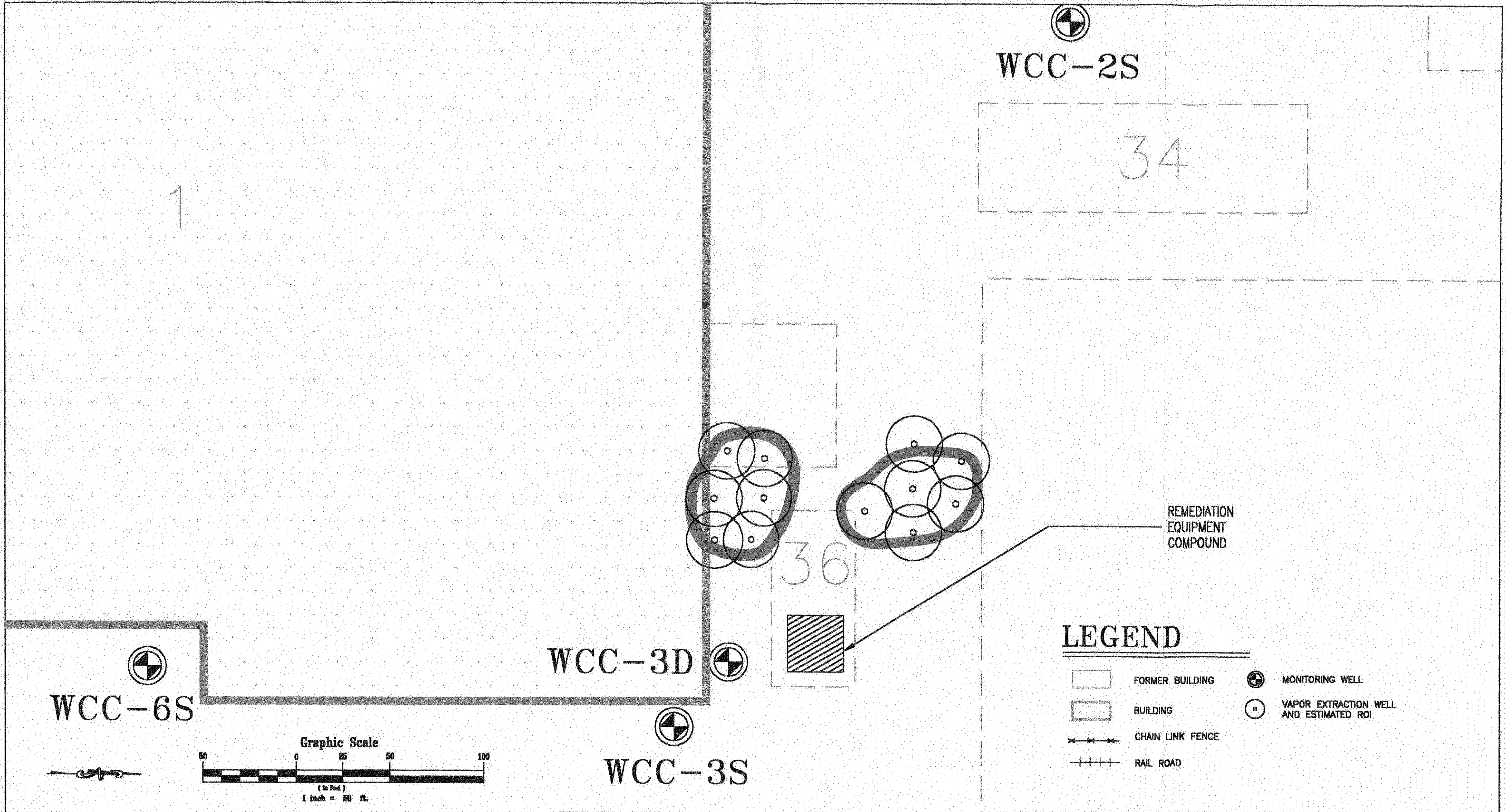
TERRA VAC
17821 MITCHELL AVENUE
IRVINE, CA 92614-6003

SOIL AND GROUNDWATER PLUMES

FORMER McDONNELL DOUGLAS C-6 FACILITY
TORRANCE, CALIFORNIA

DRAWN BY: C.CARLOS	CHECKED BY: MSH	PROJECT NO: 31-0285	FIGURE 3
APPROVED BY: MSH	DATE: 1/14/97	SCALE: AS SHOWN	

BOE-C6-0095766



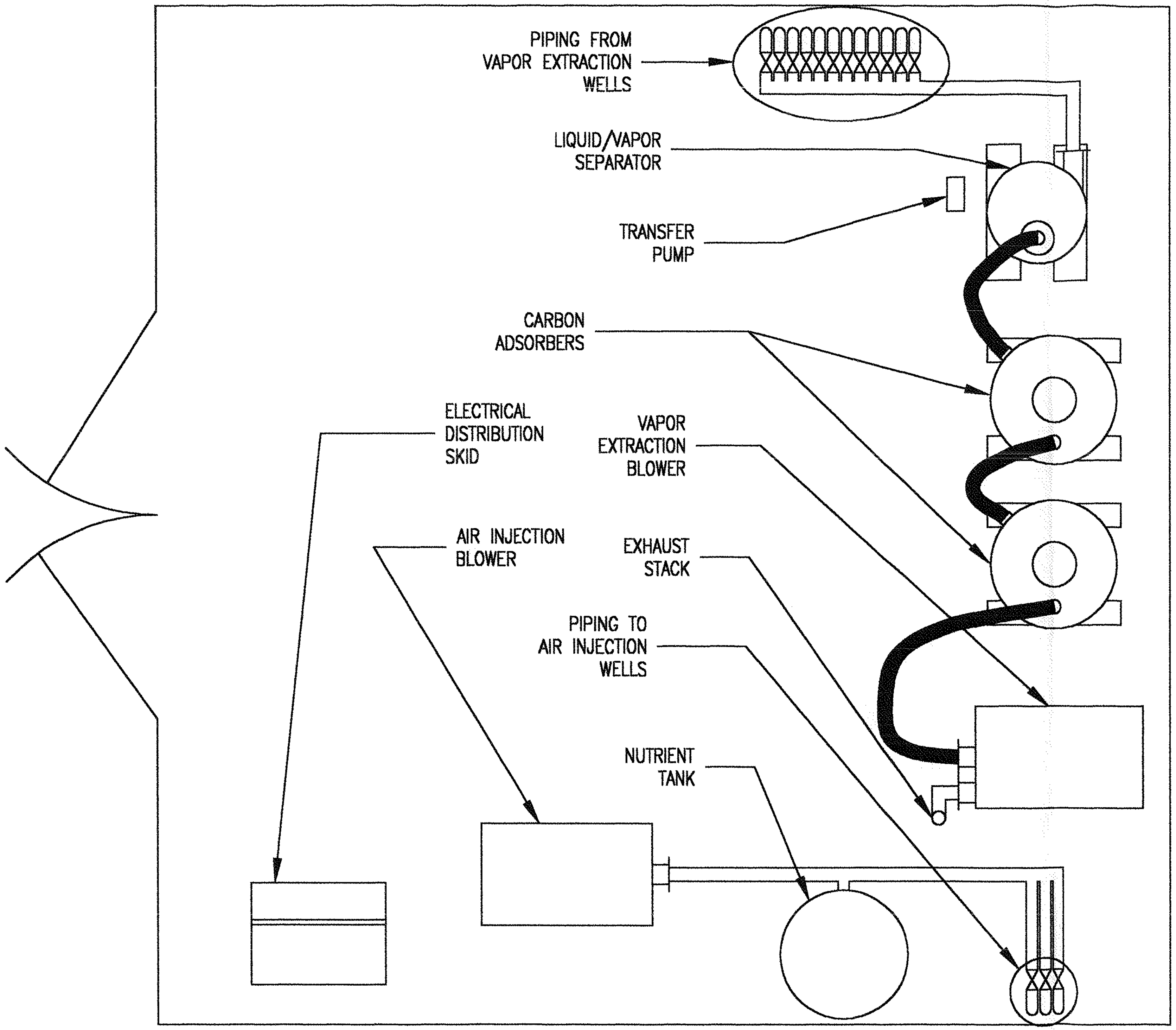
REV	DATE	BY	CHECK	APP	DESCRIPTION

TERRA VAC
17821 MITCHELL AVENUE
IRVINE, CA 92614-6003

PROPOSED VAPOR EXTRACTION WELL LOCATIONS
FORMER McDONNELL DOUGLAS C-6 FACILITY
TORRANCE, CALIFORNIA

DRAWN BY: C. CARLOS	CHECKED BY: MSW	PROJECT NO: 31-0285	FIGURE 4
APPROVED BY: MSW	DATE: 1/14/97	SCALE: AS SHOWN	

BOE-C6-0095767

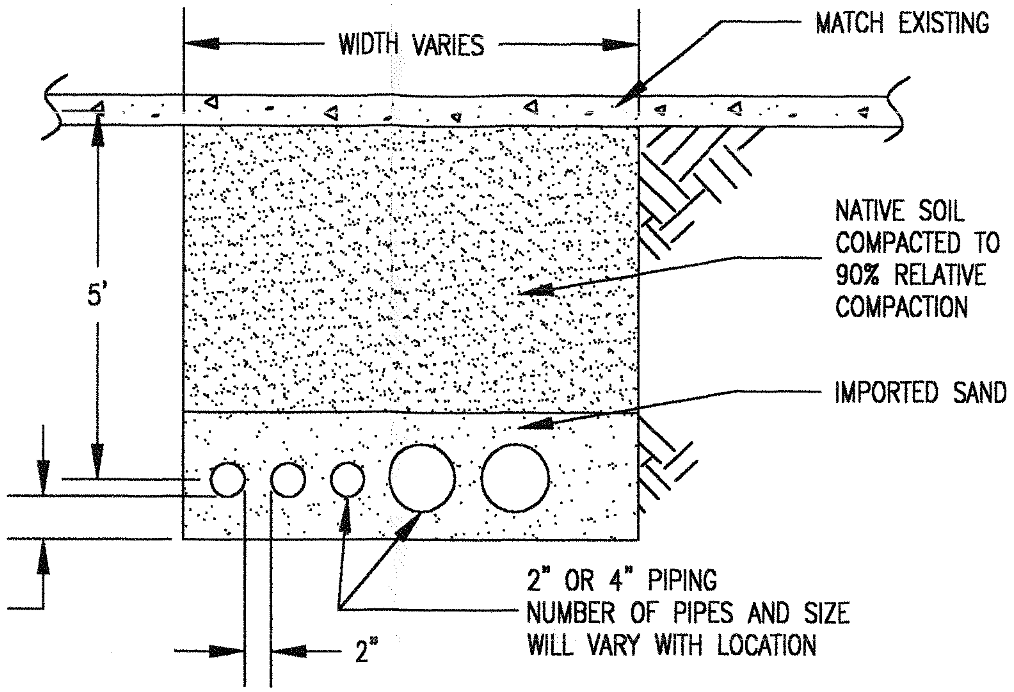


NOTE:
1) PIPING IS NOT DRAWN TO SCALE
2) ALL EQUIPMENT DIMENSIONS ARE APPROXIMATE

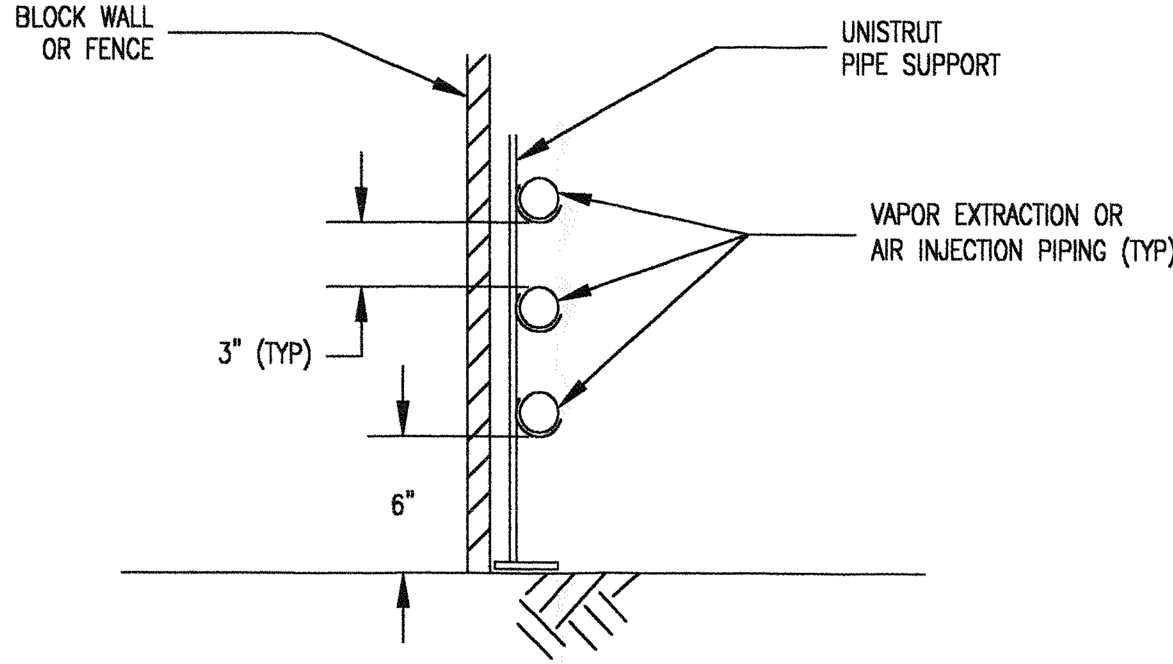
Graphic Scale

4 0 2 4 8

(In Feet)
1 inch = 4 ft.



TRENCH DETAIL
NO SCALE



ABOVE GROUND PIPING DETAIL OUTSIDE TREATMENT COMPOUND
NO SCALE

REV	DATE	BY	CHECK	APP	DESCRIPTION

TERRA VAC
17821 MITCHELL AVENUE
IRVINE, CA 92614-6003

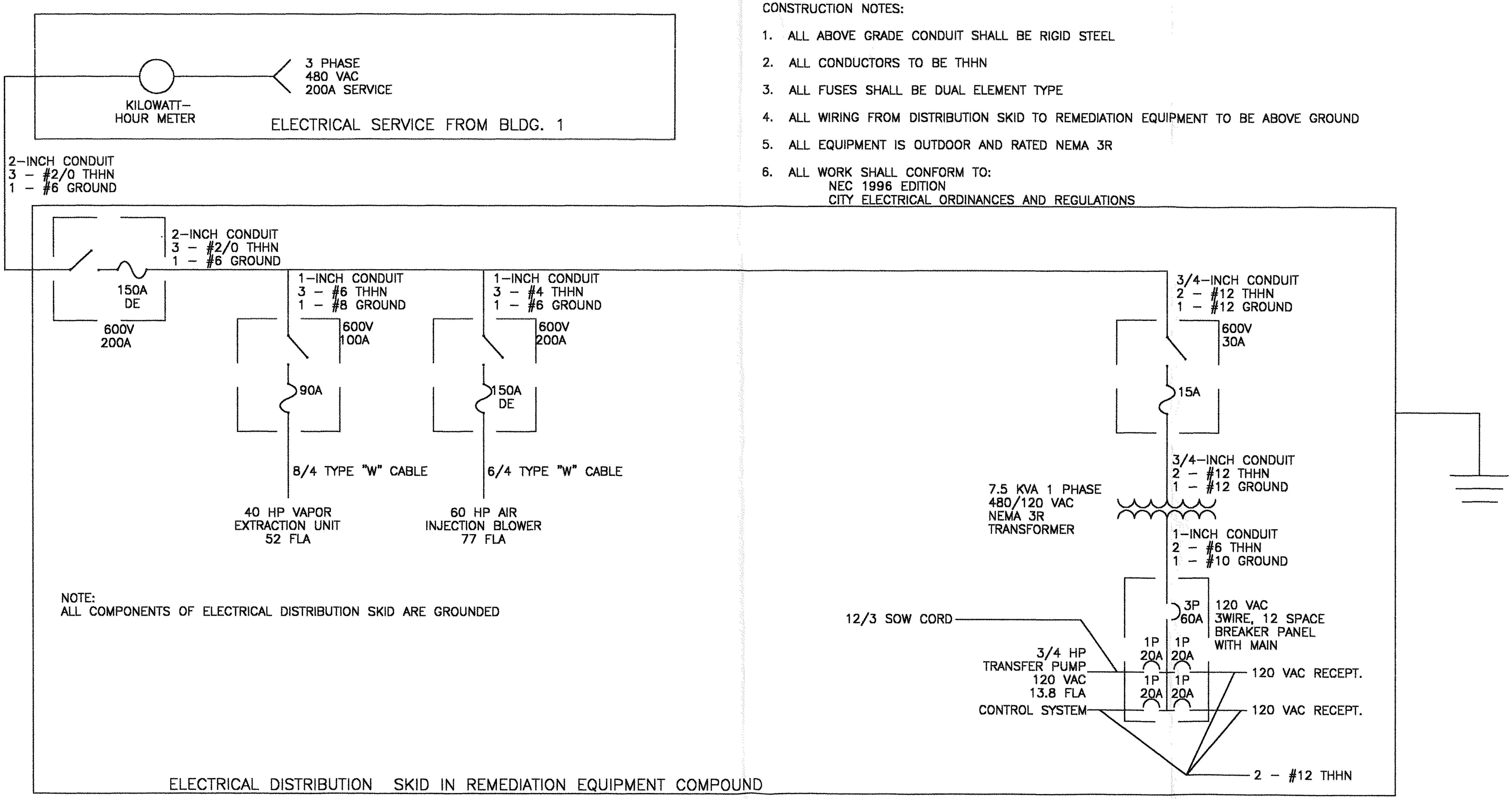
REMEDIATION SYSTEM COMPOUND
AND DETAILS
FORMER McDONNEL DOUGLAS C-6 FACILITY
TORRANCE, CALIFORNIA

DRAWN BY: MSH	CHECKED BY: MSH	PROJECT NO: 31-0285	FIGURE 5
APPROVED BY: MSH	DATE: 1/12/98	SCALE: AS SHOWN	

BOE-C6-0095768

CONSTRUCTION NOTES:

1. ALL ABOVE GRADE CONDUIT SHALL BE RIGID STEEL
2. ALL CONDUCTORS TO BE THHN
3. ALL FUSES SHALL BE DUAL ELEMENT TYPE
4. ALL WIRING FROM DISTRIBUTION SKID TO REMEDIATION EQUIPMENT TO BE ABOVE GROUND
5. ALL EQUIPMENT IS OUTDOOR AND RATED NEMA 3R
6. ALL WORK SHALL CONFORM TO:
   NEC 1996 EDITION
   CITY ELECTRICAL ORDINANCES AND REGULATIONS



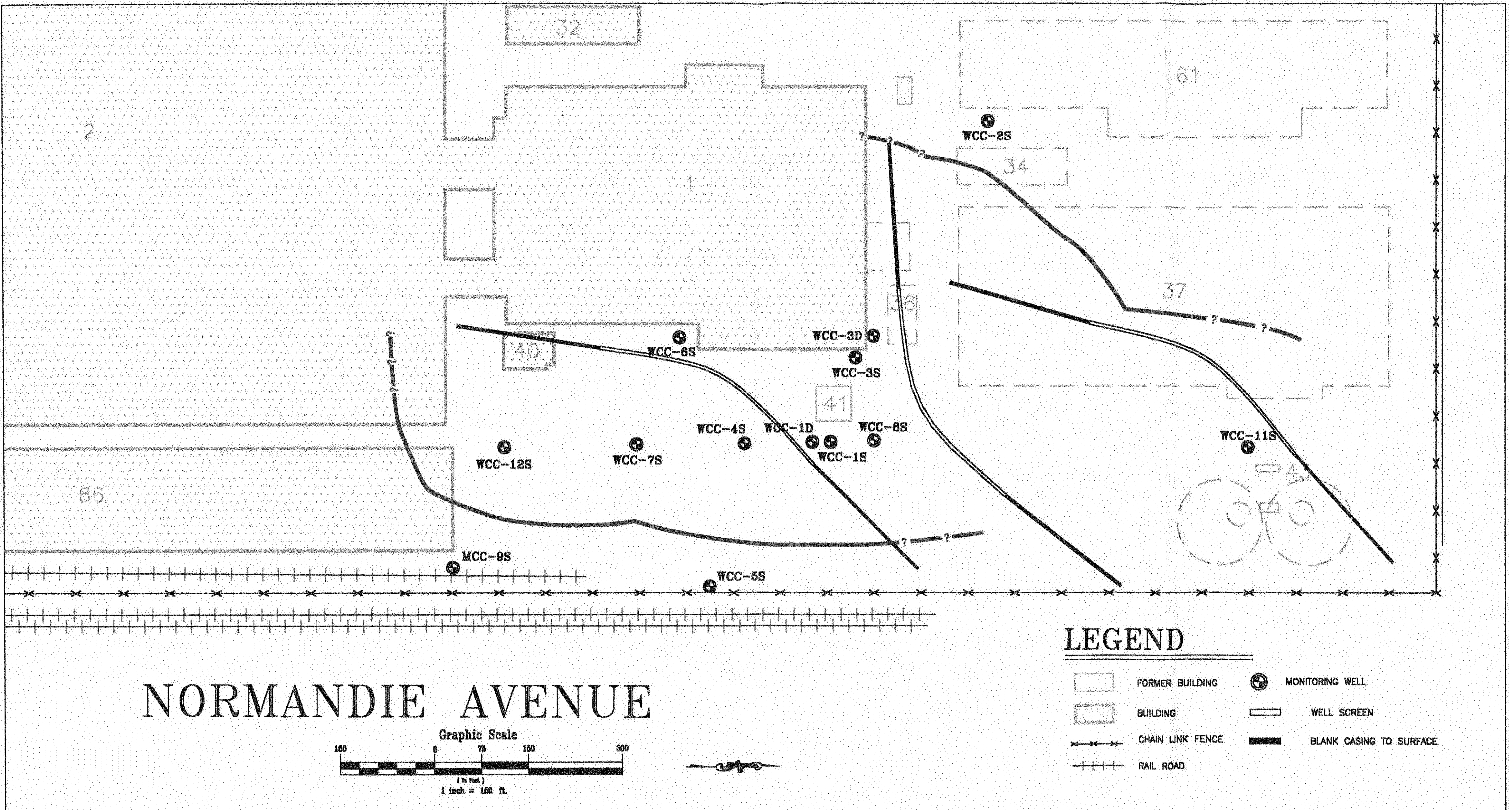
REV	DATE	BY	CHECK	APP	DESCRIPTION

TERRA VAC
17821 MITCHELL AVENUE
IRVINE, CA 92614–6003

ELECTRICAL DISTRIBUTION DIAGRAM
REMEDIATION SYSTEM
FORMER McDONNELL DOUGLAS C–6 FACILITY
TORRANCE, CALIFORNIA

DRAWN BY: MSH	CHECKED BY: JW	PROJECT NO: 31–0285	FIGURE 6
APPROVED BY: MSH	DATE: 1/8/98	SCALE: NONE	

BOE-C6-0095769



REV	DATE	BY	CHECK	APP	DESCRIPTION

TERRA VAC
17821 MITCHELL AVENUE
IRVINE, CA 92614-6003

PROPOSED HORIZONTAL WELL LOCATIONS
FORMER McDONNELL DOUGLAS C-6 FACILITY
TORRANCE, CALIFORNIA

DRAWN BY: C. CARLOS	CHECKED BY: MSH	PROJECT NO: 31-0285	FIGURE 7
APPROVED BY: MSH	DATE: 1/14/97	SCALE: AS SHOWN	

Appendix A

TERRA VAC

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Figures

TERRA VAC

STANDARD OPERATING PROCEDURES

DRILLING AND SAMPLING PROTOCOL USING A HOLLOW STEM AUGER AND SPLIT SPOON SAMPLER

Drilling Protocol

The following drilling protocol shall be observed on all Terra Vac drilling sites:

- Permits to drill soil borings will be obtained in advance from the appropriate agency as necessary
- Public Utilities Notification Service will be notified at least 48 hours in advance of drilling activities
- A Terra Vac tailgate safety meeting will be conducted prior to drilling
- All soil borings shall be initiated with a hand auger and widened with a post hole digger for the first five feet to avoid hitting underground utilities with the hollow stem auger
- Breathing space will be monitored during drilling with an organic vapor meter (as per the site Health and Safety Plan)
- Soil samples will be collected at a minimum of five foot intervals and at significant changes in lithology
- Blow counts are to be recorded for each six inches of sampler advancement
- Decontamination of samplers between sampling depths shall be ensured
- Decontamination of hollow stem augers between borings shall be ensured
- Soil cuttings and samples will be logged in a field log-book per the Unified Soil Classification System and the information entered onto a boring log form.

Hollow Stem Auger

All soil and well borings will be hand augered for the first five feet and widened with a posthole digger to the appropriate auger diameter prior to drilling. This procedure minimizes the chance of drilling through underground utilities.

Drilling will be accomplished using a truck-mounted drill rig. The specific drill rig used at each site will be chosen based on the boring depth and site specific drilling circumstances, such as drilling conditions, overhead obstructions, restricted drilling area, etc. Borings will be advanced to the depths designated in the work plan (or drilling and sampling plan) using continuous flight hollow stem augers. The appropriate diameter hollow stem augers will be chosen based on the intended purpose of the boring(s).

Soil borings drilled solely for collection of soil samples will be drilled using 6 or 8 inch outside diameter hollow stem augers. Upon completion, these borings will be backfilled completely to the surface with a concrete bentonite grout unless otherwise specified in the drilling and sampling plan for the project.

Well borings (soil borings drilled for completion as wells) will be drilled using hollow stem augers with sufficient diameter to accommodate well casings and proper annular space during well construction (as specified in the Terra Vac's Standard Operating Procedures/ Well Construction Protocol).

Unless otherwise specified in the drilling and sampling plan or work plan for the site a split spoon sampler will be used to collect soil samples at five foot intervals, (starting from the five feet depth to termination of the boring) for observation, field monitoring, and/or analysis, and to provide information for proper placement of well screens. All soil sampling equipment, sleeves, and hollow stem augers will be decontaminated in between sampling depths and boreholes to prevent cross contamination (See Terra Vac Standard Operating Procedures, Decontamination Protocol).

<u>Split Spoon Sampler</u>

Soil samples will be collected with a sampling device designed to collect undisturbed soil samples. The split spoon sampler, which is well suited for this purpose, is approximately 18-24 inches long and 2.0-3.0 inches in diameter. The sampler will be advanced ahead of the hollow stem auger in order to collect an undisturbed core sample. The sampler holds three pre-cleaned six inch long sampling sleeves, and is driven ahead of the auger by a 140 pound weight attached to a cable, which is repetitively dropped 30 inches as the sampler advances each six inches.

The number of blow counts required to advance the sampler the each six inches will be recorded in the field notebook for later inclusion on the boring log form.

A central, undisturbed, sampling sleeve will be immediately removed from the sampler for preparation as an analytical sample, where required. The exposed ends of the sampling sleeve will be immediately covered with Teflon sheets, capped with plastic caps, and taped with non-vinyl tape. The sampling sleeve will then be labeled, placed in a ziplock plastic bag, and held in pre-cooled ice chest pending delivery to the laboratory. Where laboratory duplicates are required, a scond sampling sleeve will also be prepared as an analytical sample, as described above.

Soil removed from the bottom sampling sleeve (of the sampler) will be screened for organic vapors using a Thermo Environmental Model 580B Photoionization Detector (PID) equipped with a 11.8 eV lamp (or equivalent organic vapor meter (OVM)) for field detection and measurement of organic vapors. The PID provides on-site detection of organic vapors from 0.1 to 2,000 parts per million (ppm). Measurement of organic vapors in the field will be accomplished by half-filling an 8 ounce jar or ziplock bag with the soil sample. The jar opening will be quickly covered with aluminum foil over which the screw cap will by applied to seal the jar. The sample will be allowed to set for approximately 15 minutes to allow for headspace development. The jar will be shaken at the beginning and end of the 15 minutes. The cap will then be removed and the aluminum seal will be punctured with the PID or OVA and the tip of the monitor inlet shall be inserted to a point approximately one-half of the headspace depth. Organic vapors will then be measured by observing the maximum concentration of organic vapors indicated on the instrument. The maximum PID or OVA measurement will be immediately recorded in the field notebook for later inclusion on the boring log form. The soil sample used for measuring organic vapors will be retained by Terra Vac to augment off site lithologic control. These samples will be returned to the site for proper disposal upon completion of field activities.

Soil from the upper sampling sleeve will be logged by Terra Vac's geologist using the Unified Soil Classification System.

Soil samples collected for analysis will be handled according to Terra Vac's Standard Operating Procedures (SOPs) entitled <u>Analytical Sampling Protocol for Chemical and Petrophysical Analysis of Soil Samples</u>. This SOP will be attached, if applicable.

<u>Field Documentation/Boring Logs</u>

A dedicated field notebook will be used to record significant events as they unfold in the field. All entries shall be made in the field in ink and corrections will be made through the use of a single line for crossing out errors. The field notebook should note the arrival of the drilling crews, the beginning and end of drilling, the water depth, and the timing of interruptions. Sample descriptions and all other pertinent information and problems will be recorded in this book. Upon completion of field activities, a copy of this book will be made available on request.

All borehole logging information will be immediately recorded in the field log book as drilling proceeds and samples are obtained. Logging details which will be recorded in the field will include a description of primary composition, secondary composition, sorting, color, texture, induration, plasticity, saturation, odor, visible staining, and any other distinguishing features. Lithologies will be named according to the Unified Soil Classification System (USCS). This information will later be transposed onto a boring log form and presented in the final report. All symbols used to denote specific lithologies encountered during drilling shall be described in a key included with the boring logs in the final report.

Drill Cuttings

Unless otherwise directed or specified in the drilling and sampling plan or work plan for this project, soil cuttings extracted from the subsurface during the course of this investigation will be containerized in 55-gallon Department Of Transportation (DOT) approved drums or roll off bins, as appropriate for site conditions. Non-impacted soil cuttings shall be spread at the location.

Upon completion of field activities, all drums will be transported to a pre-determined on site location and held pending proper disposal. Each drum shall be clearly marked with a "Non-Classified Waste" or client -provided label (using indelible ink) with the following information:

1) Container Number/Designation
2) Owner Name
3) Site Address and Phone Number
4) Contents
5) Corresponding well or boring number
6) Corresponding depths of soil cuttings, if applicable
7) Date Accumulated
8) Any applicable comments, (i.e., sample collection date, etc.)

An inventory of drums, along with any analytical results collected during the drilling event or otherwise requested by the client, pertaining to the contents, shall be provided to the facility operator to facilitate proper disposal.

Boring Completion Details

Depending on the drilling and sampling plan for each specific site, each boring will be completed in one of three ways:

1) Abandoned by backfilling to the ground surface with concrete/bentonite grout
2) Completed as a vapor extraction well or dual extraction well
3) Completed as a groundwater monitoring well

1) **Abandonment.** Upon reaching termination depth, each soil boring which will not be completed as a well, will be completely filled with grout until flush with the ground surface.

2) **Well Construction.** Vapor and groundwater well construction details, as applicable for this site, are provided in Terra Vac's Standard Operating Procedures/ Well Construction Protocol.

TERRA VAC

STANDARD OPERATING PROCEDURES

DECONTAMINATION PROTOCOL
FOR DRILLING, SOIL, AND GROUNDWATER
SAMPLING ACTIVITIES

Decontamination Procedures

All downhole soil and groundwater sampling equipment, including soil samplers (split spoon and continuous core), sampling tubes, well bailing and surging equipment, water level meters, etc., will be decontaminated using Alconox, trisodium phosphate (TSP) or an equivalent detergent solution between each borehole and between each sampling depth to eliminate cross contamination of samples. The following decontamination/rinsing procedure will be followed for all sampling equipment:

1. Submerge equipment in a water and Alconox (or equivalent) detergent solution and scrub with dedicated decontamination brushes
2. Rinse with tap water
3. Second rinse with tap water

Decontaminated sample sleeves and caps will be stored on a clean, polyethylene sheet or in a covered container until use. Teflon tape, used to seal the sample tubes before placement of the plastic caps, will be cut to size in the field and placed in clean ziplock bags until use.

Prior to placement or use of any drilling equipment in any boring and between borings, all downhole equipment will be thoroughly decontaminated by steam-cleaning or flushing with tap water. Hollow stem augers will be steam cleaned prior to use and between boreholes. The rinsate water will be contained in 55-gallon drums approved by the United States Department of Transportation (DOT) or a temporary holding tank and held on site pending laboratory analysis and proper disposal.

Upon completion of field activities, all drums will be transported to a pre-determined on site location for temporary storage. Each drum shall be clearly marked with a "Non-Classified Waste" or client -provided label (using indelible ink) with the following information:

1) Container Number/Designation

2) Owner Name

3) Site Address and Phone Number

4) Contents

5) Corresponding well or boring number

6) Corresponding depths of soil cuttings, if applicable

7) Date Accumulated

8) Any applicable comments, (i.e., sample collection date, etc.)

An inventory of drums, along with any analytical results collected during the drilling event or otherwise requested by the client, pertaining to the contents, shall be provided to the facility operator to facilitate proper classification and disposal.

TERRA VAC
STANDARD OPERATING PROCEDURES

DRUM CONTROL
FOR OPERATING REMEDIATION SITES

Upon generation of drums containing waste at any Terra Vac remediation site (i.e. knockout pot water, carbon, soil, etc.) the following procedures shall be implemented to ensure drum control:

Labeling

•A Terra Vac "Potentially Hazardous Waste" Label shall be immediately attached to the side of each drum. Each drum shall be clearly marked (using indelible ink) with the following information:

1) A container/number designation
   a) All drums generated at the site shall consist of consecutive numbers starting with the last drum number used at the site
   b) Each drum number used at the site shall only be issued once
   c) For re-used drums (i.e., if dumped at the site and re-used), the old drum label shall be completely covered with the new drum label. The new label will be completely filled out as for a new drum.
   d) A new drum number shall be issued to any re-used drum according to the next consecutive drum number to be issued.
   e) Previously issued drum numbers will be kept at the site in the logbook, along with sign in procedures.
2) Client/Owner address and phone number
3) Description of Contents
4) Corresponding well, boring, or vessel number (if applicable)
5) **Date Accumulated**
6) Other: Use for further description, if necessary or date sampled

Documentation Procedures

•A <u>new</u> On-Site Drum Inventory form shall be completely filled out each time new drums are generated at a site. Whenever drums are handled in the field, whether for filling, sampling, or disposition, the event will be recorded on the drum inventory form. *Documentation procedures are outlined below:*

A. Generation of Drums (Field Technicians)

1) Upon generated of new drums at the site, Field Technicians will fill out the top of the form and columns A , (B & C if applicable), D, E, and F. These columns correspond to drum number, source, depth, contents, date samples, and sample number, respectively.

B. Sampling and Analysis (Field Technicians)

1) Samples will be taken from drums filled with knock-out-pot (KOP) water on the day that they were generated.
2) The Tech will take a sample from the second drum filled with KOP water. A sample from the second drum filled will produce a representative sample from the KOP.
3) A chain of custody form will be filled out indicating the number of samples accumulated and the drums that the sample represents.
4) **The Tech collecting the sample will note the date sampled on the drum label <u>and</u> drum inventory form kept on site**
5) The Tech will notify the chemist as soon as possible (preferably the same day) that samples have been obtained.
6) The Tech will store the samples in a cooled ice-chest, and deliver them to the chemist.
7) The Chemist will arrange sample pick-up from the Terra Vac office.
8) The Chemist will receive the analytical results, record them on the drum inventory form, and determine proper disposition of the drum contents

C. Disposition of Non-hazardous Drums (Field Technicians)

1) If drum contents are non-hazardous, the Chemist will direct the Field Technicians to dump the contents on-site

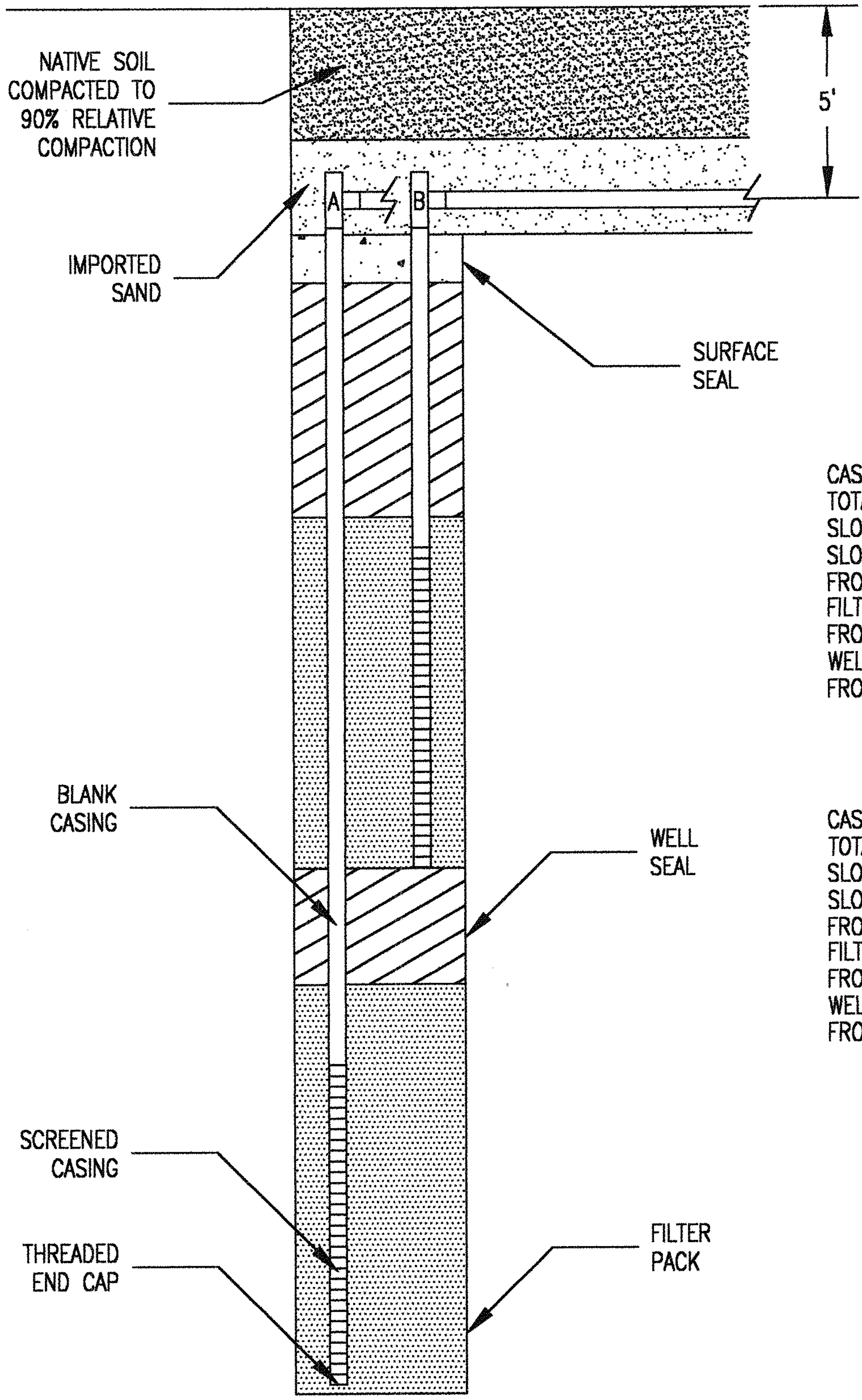
2) Upon disposition of drum contents, the Field Techs will complete columns K, L, and M (Action Taken, Date of Action, and Drum Condition) and return the form to the chemist.
3) The chemist will submit the form for filing in the appropriate project drum inventory file.

D. Disposition of Hazardous Drums (Chemist and Chemical Technicians)

1) **If hazardous**, the Tech will change the label on the drum to read "Hazardous Waste" by crossing out "Potentially" with indelible black ink.
2) The Chemist will record "hazardous, notify client", in the Action Taken (column I) of the drum inventory form.
3) The Chemist will give the drum inventory form and analytical results to the Terra Vac and Client Project Manager for proper disposition

Drum Storage Protocol

- All drums will be transported by the field techs (using a drum dolly kept on-site), to a pre-determined on-site location for temporary storage.
- **Full drums shall not be stored on-site for more than 90 days from the date of generation of the contents. This is a violation of Hazardous Waste Control Laws and shall be immediately reported to the chemist and project manager if observed by any personnel in the field!!**
- Aesthetics are an important part of Terra Vac Remediation equipment maintenance. Any field tech who performs work at the site shall be responsible for making sure drums are stored in a neat and orderly fashion. If drums are not stored in an orderly fashion upon arrival of the techs, the situation should be corrected before leaving the site.
- All drum lids shall be secured, whether full or empty, and drums shall be stored in an upright position.
- Dirty, rusty, or otherwise inoperative drums shall be reported on the drum inventory form for replacement, as needed. Inoperative drums will be removed from the site as soon as possible.
- All drums with contents shall be properly labeled and shall have an accompanying drum inventory form on-site and in the office.



WELL A

CASING TYPE:	2-in PVC
TOTAL DEPTH:	41
SLOT SIZE:	0.020-in.
SLOT SPACING:	0.125-in
FROM: 30	ft TO: 40 ft
FILTER PACK:	No. 3 MONTEREY SAND
FROM: 29	ft TO: 41 ft
WELL SEAL:	BENTONITE PELLETS
FROM: 26	ft TO: 29 ft

WELL B

CASING TYPE:	2-in PVC
TOTAL DEPTH:	26
SLOT SIZE:	0.020-in.
SLOT SPACING:	0.125-in
FROM: 19	ft TO: 25 ft
FILTER PACK:	No. 3 MONTEREY SAND
FROM: 18	ft TO: 26 ft
WELL SEAL:	BENTONITE PELLETS
FROM: 8	ft TO: 18 ft

REV	DATE	DESCRIPTION

TERRA VAC
17821 MITCHELL AVENUE
IRVINE, CA 92614-6003

TYPICAL WELL INSTALLATION DETAILS
DUAL COMPLETION WELLS
FORMER McDONNELL DOUGLAS C-6 FACILITY
TORRANCE, CALIFORNIA

DRAWN BY: MSH	CHECKED BY: MSH	PROJECT NO: 31-0285	FIGURE APP. A-1
APPROVED BY: MSH	DATE: 1/27/97	SCALE: NONE	

Fort Worth, Texas

Darien, Illinois

Marietta, Georgia

Irvine, California

San Juan, Puerto Rico

San Leandro, California

Seattle, Washington

Tampa, Florida

Temperance, Michigan

Westford, Massachusetts

Windsor, New Jersey